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Lights out: Impact of the August 2003 power outage on mortality in New York, NY

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Abstract

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Background

Little is known about how power outages affect health. We investigated mortality effects of the largest US blackout to date, August 14–15, 2003 in New York, NY.

Methods

We estimated mortality risk in New York, NY, using a generalized linear model with data from 1987–2005. We incorporated temperature predictors, including weather and long-term and seasonal mortality trends.

Results

During the blackout, mortality increased for accidental deaths (122%; 295% confidence interval = 28%–297%) and non-accidental deaths (11%; 95% confidence interval = 3%–19%), resulting in approximately 90 excess deaths. Increased mortality was not from deaths being advanced by a few days; rather, mortality risk remained slightly elevated through August 2003.

Discussion

To our knowledge, this is the first analysis of power outages and non-accidental mortality. Understanding the impact of power outages on human health is relevant, given that increased energy demand and climate change are likely to put added strain on power grids.

Power blackouts are likely to increase as growing energy use stresses aging power grids.[1] Climate change could also increase power outages,[2] and energy infrastructure may be targeted by national security threats.[3] However, we know little about how power outages affect health. Studies have reported increases in accidental deaths and injuries, including motor vehicle mortality (CO poisoning,[4] food poisoning,[5] and hyperthermia[6] during power outages, as well as increased respiratory hospitalizations.[4] Calls to emergency services[7] and poison control[8] can increase, although this may reflect the inability to contact primary health providers.[7] While one article showed graphically that mortality increased during the New York 2003 blackout,[9] to our knowledge, there has been no analysis of the effect of blackouts on non-accidental deaths including non-accidental (i.e., disease-related) causes. Furthermore, estimated death tolls for disasters (e.g., hurricanes) generally include only directly attributable deaths (e.g., drowning),[10] even though disasters often also cause post-event outages.[11] Stronger effect mortality from non-traumatic causes, current fatality estimates for disasters may be substantially underestimated, particularly for developed countries where disaster-related deaths are considered relatively rare.

We investigated mortality in New York, NY, during the largest blackout in US history (August 14–15, 2003).[12] This was the first citywide blackout of New York, NY, since 1977[13] and constituted a natural experiment—power was available until 4:11 pm on August 14, and then remained off for 25 hours.[12] To control for temperature,[14] we compare population mortality on blackout days to days with power.

Methods

Go to ↓

Data

Mortality data were obtained from the National Center for Health Statistics[15] through the National Mortality, Morbidity, and Air Pollution Study.[16] For New York, NY, observations for 1987–2005. Data include daily mortality counts by age (<65, 65–74, >75 years) and cause of death: accidental, cardiovascular, respiratory, and non-cardiorespiratory (ICD-9 codes).

Temperature and dew-point temperature data are from the National Climatic Data Center.[17] We used observations monitoring the same power outage study period (Table 2 and eFigure 1 [http://links.lww.com]) and averaged daily data across all reporting monitors to estimate community-wide weather. We adjusted dew-point temperature for temperature,[18] as these variables were highly correlated ($R^2 = 0.91$).

Because pollution can affect mortality,[19] we obtained ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter <10 microns in aerodynamic diameter (PM_{10}), and fine particles ($PM_{2.5}$) for 1999–2005. Based on 2001–2005 from the US Environmental Protection Agency's Air Quality System.[17] We included only these variables reporting data August 14–16, 2003, excluding source-oriented monitors (eFigure 1 and eTable 1, http://links.lww.com).

Methods

We modeled daily mortality rates using a Poisson distribution with overdispersion, based on methods used to study health effects of air pollution and heatwaves.[12,21] We modeled blackout days using an indicator variable=1 for blackout days, 0 otherwise. We controlled for seasonality including day-of-week, temperature, dew-point temperature, and long-term and seasonal mortality trends (details in the eAppendix, http://links.lww.com). We estimated the blackout effect on mortality risk overall with the power outage, comparing mortality on blackout days to other days. We tested sensitivity of results using a model with temperature at lags ranging from same-day to four days previous. In this model, we included temperature lags using a distributed lag model with strata: same day and average of lags 1–4.[22]

To estimate number of deaths related to the blackout, we calculated baseline mortality on blackout days (the expected mortality had the blackout not occurred) and then estimated excess deaths associated with the blackout-relative risk associated with the blackout multiplied by excess deaths. Uncertainty in estimates of uncertainty for excess mortality incorporated uncertainty in the blackout's association with mortality and in baseline mortality. We estimated effects by age group and cause of death through stratified analyses.

Separately, we considered changes in mortality rates through 31 August 2003, to investigate evidence of displaced mortality (harvesting).[23] Following methods used to study mortality displacement following heatwaves,[24] we fit a spline to a 29-day period centered on 15 August 2003. We placed knots more closely near the blackout, since effects long-term were not generally evident (Figure 1).

Since heatwaves can affect mortality beyond single days of heat,[12,21] we investigated whether the blackout coincided with a heatwave, defined as 2 consecutive days with temperatures in the 95th percentile of year-round temperatures in New York, NY.[12,21]

Previous work using airborne measurements found decreased pollution in the Northeast during the blackout, possibly from power-plant shutdowns.[25] We compared ground-level measurements of O_3, NO_2, SO_2, PM_{10}, and CO during the blackout to distributions of typical levels for the area and season (August 2001–2005 and 2000–2003).

Results

Go to ↓

During the blackout, total mortality rose 28%, resulting in approximately 90 excess deaths (Figure 1, Table 1). Effect estimates were almost identical using a more complex model that included temperature effects at longer lags (eTable 4, http://links.lww.com). Results did not change substantially when we removed excess deaths were primarily from non-accidental causes. While all ages were affected, those 65–74 years were particularly susceptible (Table 1). We found no evidence of short-term mortality displacement; rather, mortality remained slightly elevated through August 2003.

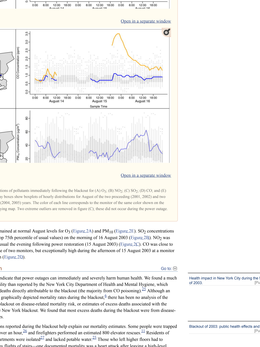

Figure 1

Daily mortality counts during August 2003 (in red) compared with average August mortality rates for 12 other years (1987–2005, blue non-accidental mortality, and 1/3 accidental mortality). The blackout is the vertical dashed line (black line) and interquartile range (hatched area) of a seven-day moving average of mortality in August of the two preceding years (2001–2002) and two following years (2004–2005). Yellow highlighted days were

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Table 1

Effects of the August 14–15, 2003, blackout on mortality risk in New York, NY, by age and cause of death

	Baseline mortality: estimated mortality for the blackout period, had the blackout not occurred	Percent increase in mortality comparing the black period to other periods (95% confidence interval)	Excess mortality during the blackout period by deaths (95% confidence interval)[a]
All ages	319	28 (13 to 44)	90 (46 to 138)
Age (years)			
<65	91	30 (6 to 59)	27 (6 to 53)
65–74	57	61 (21 to 110)	35 (8 to 62)
>75	175	23 (6 to 42)	39 (10 to 73)
Cause of death			
All non-accidental	309	23 (12 to 41)	70 (37 to 125)
Cardiovascular	148	26 (7 to 48)	38 (10 to 71)
Respiratory	21	12 (−27 to 89)	3 (−6 to 15)
Non-cardiorespiratory	140	27 (6 to 48)	37 (11 to 66)
Accidental	10	122 (28 to 297)	12 (3 to 23)

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[a]Confidence intervals of excess mortality incorporate uncertainty in estimates of baseline mortality and of the risk associated with the blackout.

Temperatures were hot but not extreme for a typical August day in New York (eFigure 2, http://links.lww.com). Neither the 14th or 15th of August was a heatwave, making adjustment for added mortality from heatwaves unnecessary. Dew-point temperatures were lower than typical, but not extreme, nor had any pollutant for the afternoon of 14 August through the morning of 15 August 2003. However, there are data for the morning of 14 August and immediately following power restoration (15 August). We compared pollutant concentrations for all available data on 14–16 August, 2003 to distributions of typical levels (August 2001–2002, 2004–2005) (Figure 2).

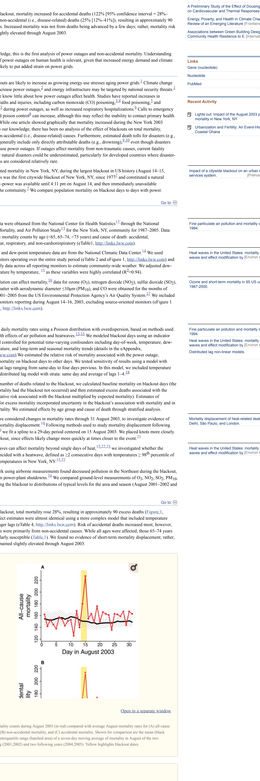

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Figure 2

Concentrations of pollutants immediately following the blackout for (A) O_3, (B) NO_2, (C) SO_2, and (D) PM_{10}. Data boxes show historical hourly distributions for August of the two preceding years (2001–2002) and two following (2004, 2005) cases. The color of each box corresponds to the month of the same color shown on the accompanying map. Two extreme outliers are removed in figure (C); these did not occur during the power outage.

Pollution remained at normal August levels for O_3 (Figure 2A) and PM_{10} (Figure 2B). SO_2 concentrations were high (top 75th percentile of usual values) on the morning of 16 August 2003 (Figure 2D). NO_2 was higher than usual the evening following power restoration (15 August 2003) (Figure 2C). CO was close to normal at one of two monitors, but exceptionally high during the afternoon of 15 August 2003 at another in Manhattan (Figure 2D).

Discussion

Our results indicate that power outages can immediately and severely harm human health. We found a much higher mortality than reported by the New York City Department of Health and Mental Hygiene, which reported 15 excess deaths during the blackout and heatwave combined.[26] Our estimate is likely more accurate: study plausibly applied mortality rates during the blackout.[3] There has been no analysis of the effects of a blackout on disease-related mortality risk, or estimates of excess deaths associated with the August 2003 New York blackout. We found that most excess deaths during the blackout were from disease-related causes.

The conditions experienced during the blackout help explain why mortality risk would have been trapped indoors, as those[27] and firefighters performed an estimated 800 elevator rescues.[28] Residents in high-rise apartments were isolated[29] and lacked potable water.[30] Those who left higher floors had to navigate[31] dark stairwells and encountered crowding in the streets.[32] Many were physically exhausted.[28]

The blackout also complicated the management of illness, which may help explain the range of causes of death. Most food sources and pharmacies were closed—a serious problem for diabetics and anyone low on medications.[33] Many New York, NY residents were trapped in subways for hours.[34] Others were evacuated,[35] and hospitals and healthcare-required residents to use their backup generators.[36] Some hospital service failed during part of the blackout,[37] it was difficult to contact emergency services. Four of the 75 hospitals in New York, NY, lost power for part of the blackout.[38] And hospital emergency rooms with power were overcrowded with people seeking electricity for medical equipment.[39]

Both heat and air pollution can affect mortality.[40,41] Our estimate of excess mortality during the blackout cannot be explained solely by heat. We controlled for temperature in the model, and the blackout did not coincide with a heatwave. However, increased exposure to heat during the power outage (i.e., lack of air conditioning) could have contributed to excess deaths. Although we found no evidence that short-term pollution exposure were responsible, we were unable to fully analyze pollutant levels. We found no evidence of elevated levels of some pollutants on the day following the blackout. While this blackout may have destroyed pollution from long-range transport, as was observed in the Northwest,[25] local pollution sources were also affected, including traffic, public transportation, airlines, and generator use.[42,43]

Mortality risk during the blackout was likely caused by the blackout, and therefore excess deaths pollutants rather than confounders in the relationship between the blackout and mortality.

Among US cities, New York, NY, may be particularly vulnerable to risks of many high-rise buildings and substantial dependence on public transportation. Other power outages have lasted longer or been accompanied by more extreme weather.[44] Future research may determine if health effects observed during this blackout are found during other blackouts and in other communities. Our findings indicate that health impacts of power outages have been underestimated, which has implications for emergency planning as well as for assessment of the full impact of national disasters and other events related to blackouts.

Acknowledgments

Go to ↓

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Footnotes

Go to ↓

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